TECH TIP

POST ARREST CARE: A PERFECT SCENARIO TO APPLY "THE RULE OF TWENTY"

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At the conclusion of cardiopulmonary resuscitation (CPR), there is hopefully a thrilling moment when we have achieved return of spontaneous circulation (ROSC). This joyous moment quickly becomes tempered with the panicked thought...."What Now?". While the survival to discharge rate in human medicine for people who survived the initial arrest episode is only 30-40%, this figure is markedly lower in veterinary medicine with survival rates at 2-10%. While the cause of the arrest and the presence of end stage underlying disease need to be considered in the ultimate outcome, these figures suggest that there is much room for improvement in veterinary post arrest management. "The rule of twenty" is a concept introduced by Dr. Rebecca Kirby in the context of sepsis and the Systemic Inflammatory Response Syndrome (SIRS). It is a list of parameters which have been recognized as essential for critically ill patients in general. It is however, a great rule of thumb for any sick patient, but is an excellent outline in the approach to a post arrest patient.

The first step in managing a post arrest case is to determine and address the underlying cause of the arrest. The following guidelines should be applied to the patient and considered in the context of the underlying disease process. One must always remember, however, that these patients are suffering from both their underlying disease and the effects of having died and undergone CPR. This means they had a period of major organ (including brain, heart, gastrointestinal tract and kidney) ischemia and potentially some trauma sustained from the CPR itself (ie. chest compressions causing pulmonary contusions or rib fractures - good chest compressions can do this!). They will also systemically suffer from reperfusion injury resulting in intracellular organelle and membrane damage which will ultimately result in organ dysfunction and potentially failure. The immediate post arrest period is a critical period in which all of these factors must be considered and addressed concurrently.

Below is Dr. Rahilly borrowing a page from Dr. Kirby's book: an application of the rule of twenty to post arrest cases.

1. **FLUID BALANCE:** Careful administration of fluids including isotonic crystalloids, hypertonic saline, synthetic or natural colloids and blood products is essential to post arrest care. Reperfusion injury may result in endothelial damage and vascular leak into the interstitium. Serial patient assessment to monitor interstitial hydration status as well as close attention to fluid losses (urine quantification in a collection system or weighing of bedding, vomiting/ diarrhea, and panting resulting in increased insensible losses) is necessary. The RECOVER initiative concluded that there is no clear consensus based on the evidence on the type or amount of fluids that are need post arrest, but it is clear that most cases need some fluids. The only exception would include cases which are fluid overloaded or in congestive heart failure as part of the reason for the arrest event. The type of fluids administered should be tailored to each case.

2. **ANALGESIA:** Many patients are comatose or severely neurologically depressed following an arrest episode due to a period of cerebral ischemia. One should consider the degree of reaction/awareness to painful stimuli as well as the presence of injury (existing pre arrest or potentially incurred during CPR) and treat accordingly. The RECOVER initiative did not specifically look at analgesic medications used in the post arrest period, but analgesia at this point is similar to that of many critically ill

patients. Reversible agents such as pure mu agonists (Fentanyl, Remifentanyl, Hydromorphone, Oxymorphone, Methadone) should be considered so that they can be completely reversed if arrest recurs or the degree of sedation is deemed inappropriate (ie. hypoventilation). One should keep the respiratory depression of opioids in mind and titrate medications to effect so as not to contribute to hypoventilation and hypercapnea. Non-steroidal anti-inflammatory agents which may contribute to gastrointestinal or renal injury should be avoided. Other agents to consider are Ketamine or Lidocaine infusions. Ketamine increases metabolic demand and therefore is not an ideal choice when one considers the need to maximize adequate cellular oxygenation. There is also controversy surrounding Ketamine use in cases with brain injury (and post arrest cases suffered some brain injury in the form of ischemia!). Lidocaine (initially as a bolus of 1-2mg/kg followed by a CRI of 50mcg/kg/min) is a good choice in dogs as it provides analgesia with minimal respiratory or cardiac compromise and can serve as an anti-oxidant.

3. **ONCOTIC PRESSURE:** Adequate Colloid Oncotic Pressure (COP ~17mmHg) is necessary to help maintain intravascular volume and minimize fluid leakage into the interstitium, which can decrease organ function. Oncotic pressure can be augmented through the administration of synthetic colloids, plasma and albumin infusions (canine or human). Careful consideration of protein losses and patient COP relative to colloid administration is necessary as endogenous albumin production is triggered by low COP; over-zealous augmentation of oncotic pressure with synthetic colloids can therefore stifle the production of albumin. Patients with high protein losses (severe peritonitis/ diarrhea) may need 1-2mL/kg/hr of a synthetic colloid while those with minimal to no on-going protein losses but a low total protein due to underlying disease or historic protein losses often only require 0.5-1mL/kg/hr.

4. **ALBUMIN CONCENTRATION:** Albumin contributes the bulk of colloid oncotic pressure (COP), but also has important functions in wound healing, systemic buffering and drug transportation. Hypoalbuminemia has been shown to be a risk factor for mortality in multiple disease states. Endogenous albumin production can be maximized clinically through careful titration of colloids (see above) and providing nutrition. Anorexia causes albumin production to stop within 24 hours and no further production will occur until nutrition is instituted.

5. **BLOOD PRESSURE (CARDIOVASCULAR SYSTEM):** Ensuring adequate tissue perfusion is absolutely necessary for the recovering brain and other major organ systems in the post arrest patient. Analysis of the evidence in the RECOVER initiative found that normal, or perhaps even mild to moderate hypertension (MAP >150mmHg) results in better neurologically intact survival. Vasopressor and/or cardioactive drugs may be required to achieve this outcome. Which drugs and the optimal goal blood pressure are still unknown. It is clear, however that hypotension is unacceptable. Monitoring tissue perfusion through such parameters such as lactate, base excess and central venous oxygenation improve the sensitivity of detecting cellular hypoxia and on-going occult shock.

6. **BODY TEMPERATURE:** The RECOVER initiative found that there is evidence to suggest that post arrest hypothermia initiated as soon as possible in comatose post arrest patients and maintained for >12 hours is beneficial for survival. The recommendation is to cool to approximately 32-34 degree C: 89-93 degree F. Veterinarians should note, however, that these numbers are in human patients and experimental cases and not in clinical small animal patients who are warmer than humans in health. Details of how to achieve the hypothermia and the duration of which are not known. Practically for small animals in a clinical setting, achieving hypothermia is often not a challenge as many cases post arrest are cold. My approach is to not actively re-warm them unless they become <92 degree F. If re-warming is necessary, it should be done slowly (<1 degree C per hour).

7. **VENTILATION, OXYGENATION:** Evidence as presented in the RECOVER initiative demonstrates that profound hyperventilation (to a low CO2) and hypoventilation (with a high CO2) result in decreased neurologic recovery. The current recommendations are to aim to achieve mild to moderate hyperventilation (mildly low CO2) if an animal is mechanically ventilated or normocapnea. Similarly, the precise goal
for oxygenation is unclear. What studies have demonstrated,
however, is that hyperoxia and hypoxia are detrimental. Hyperoxia may result in exacerbation of reperfusion injury with the generation of more reactive oxygen species. Hypoxia may result in decreased oxygen delivery to the tissues. Careful pulse oximetry and/or arterial blood gas monitoring to evaluate oxygenation is imperative in post arrest cases.

8. **ELECTROLYTES, ACID-BASE BALANCE:** There are currently no guidelines for goal electrolyte levels or acid-base parameters in post arrest patients. As critically ill patients, careful attention to sodium levels as a marker of free water status is a necessity. Potassium, calcium, phosphorus and magnesium should also be monitored as these electrolytes all function in important physiologic activities including smooth muscle contraction and vascular tone, cellular energy production, and skeletal muscle strength necessary for adequate ventilation. Acidosis may occur due to hypoventilation or decreased perfusion in these patients and should be treated accordingly as it can result in cardiovascular depression.

9. **CARDIAC RATE, RHYTHM, FUNCTION:** Myocardial ischemia during the arrest may result in arrhythmias and/or decreased systolic function following ROSC. Continuous ECG monitoring for arrhythmias and treatment as indicated is necessary. Inotropic medications such as Dobutamine infusions may also be necessary if there is depressed cardiac contractility post ischemia.

10. **COAGULATION:** Endothelial and cellular damage through ischemia and reperfusion injury may result in coagulation disorders and disseminated intravascular coagulopathy (DIC) in post arrest patients. Monitoring of platelet levels and coagulation parameters is important to attempt to "catch" DIC in its earlier phases and treat accordingly. Plasma administration in cases which show clotting factor consumption through elevation of clotting times should be considered. Theoretically, clinicians should also consider anticoagulant therapy as the inflammation associated with reperfusion injury may trigger a hypercoagulable state.

11. **RENAL FUNCTION:** Renal function can be monitored directly through quantification of urine output and regular assessment of BUN and creatinine. It is important to monitor these values daily as urine function may decrease in the days following a renal ischemic event, such as cardiopulmonary arrest. Renal function is also indirectly evaluated in the assessment of electrolytes and acid-base status as tubular injury may result in diuresis or metabolic acidosis in the absence of a rising BUN or creatinine.

12. **GASTROINTESTINAL INTEGRITY:** The gastrointestinal tract of the dog is very susceptible to ischemia and is considered to be the source of systemic toxins/inflammatory cytokines and activated white blood cells following an ischemic incident and subsequent reperfusion. Antibiotic coverage to "protect" from bacterial translocation from the gastrointestinal is somewhat of a controversial topic in critical care as the development of resistance is a concern, and the question of prophylactic antibiotic use was not specifically addressed in the RECOVER initiative. Measures to improve intestinal integrity, such as enteric nutrition and ensuring adequate gastrointestinal perfusion through cardiovascular optimization, however, make sense as supportive measures which are unlikely to cause harm.

13. **NUTRITION:** Although nutritional status of the post arrest patient was not specifically addressed in the RECOVER initiative, adequate nutrition in critically ill patients is known to maximize immune function and is necessary for endogenous albumin production. Enteric feeding is the optimal route of nutrient administration as it helps to maintain intestinal motility, function and integrity. Calculation of the patients' resting energy requirements (RER) with the goal of feeding 50-100% of RER is recommended, as over-feeding can result in increased CO2 production in an animal with potentially compromised
ventilatory reserves to maintain normocapnea. Over-feeding in a neurologically or respiratory compromised animal may result in a respiratory acidosis.

14. **GLUCOSE:** Blood glucose levels should be monitored frequently to ensure normoglycemia as hypoglycemia can be detrimental to neurologic function and recovery and hyperglycemia has been shown to be detrimental to patient outcomes. Dextrose supplementation and conversely short-acting insulin should be utilized as needed to maintain normal blood glucose.

15. **ANTIBIOTICS/WBC COUNT:** Complete blood counts should be performed every 2-3 days during the critical period (more often if indicated) and peripheral blood smears should be evaluated daily for a manual white blood cell count and evidence of toxic change and/or left shifting. Judicious antibiotic use as indicated for the underlying disease state or developing nosocomial infections is prudent.

16. **RED BLOOD CELLS:** A packed cell volume should be monitored at least twice a day to watch for anemia and as an indicator (along with total solids) of hydration status. Clinicians should have a quick trigger for red blood cell transfusions in post arrest cases as ensuring adequate oxygen delivery is a top priority.

17. **DRUG DOSAGE, METABOLISM, INTERACTIONS:** As with all critically ill patients, one must consider the entire physiologic picture of post arrest cases. Drug dosages or frequency may need to be adjusted based on liver or renal dysfunction and associated increased half-life of hepatically metabolized and/or renally excreted medications. The albumin level should also be considered for drugs which are highly protein bound.

18. **MENTATION:** Many post arrest cases will have decreased mentation and potentially even be in a coma. The clinician must monitor these cases closely to ensure adequate ventilation and gag reflex and consider mechanical ventilation or intubation with close monitoring if either of these parameters are sub-optimal. The RECOVER initiative evaluated the prophylactic use of anti-seizure medications post arrest as seizures are known to be relatively common in humans following ROSC. There is currently no evidence indicating a benefit to seizure prophylaxis post arrest. However, there are some bundled therapy studies that evaluated seizure prophylactic medications (Thiopental and Phenytoin) which used these medications among other interventions and found potential benefit. It is not clear, however, if it was the seizure prophylaxis specifically, another component of the bundle or the entire package which allowed for the benefit. Cerebral function and signs of elevated intracranial pressure should be monitored closely. Signs of elevated intracranial pressure include pupillary changes (miosis followed by anisocoria and mydriasis with progressive intracranial pressure elevations), limb and/or jaw rigidity, decreasing mentation and hypertension with concurrent bradycardia. Suspected elevations in intracranial pressure should be treated with hypertonic saline (3-4mL/kg) if the patient is hemodynamically unstable or mannitol (1g/kg) and/or hypertonic saline if the patient is stable. Brain protective measures such as keeping the head elevated 15-30° and making sure there are no bends of

the neck should be taken to ensure adequate cerebral venous drainage in order to minimize intracranial pressure.

19. **NURSING ORDERS:** Detailed nursing orders ensuring constant attention to mental and hemodynamic status are essential. For comatose patients, measures including applying eye lubrication and anti-bacterial oral rinses to avoid ulcers and bacterial colonization should be taken. Regular turning of the patient allows for improved pulmonary function and passive range of motion exercises keeps interstitial fluid moving and lymphatics flowing.

20. **TENDER LOVING CARE:** The most important, but hard to directly institute on our treatment sheets, aspect of critical care is tender loving care. Clean bedding and ensuring that the patient is comfortable, free from anxiety, and clean and dry at all times decreases the risk of nosocomial infection and will ultimately contribute to patient well-being and hopefully survival.

As is evidence by the extensive list of parameters to concurrently monitor and consider in post arrest patients, these cases are intensive. There are no studies in veterinary medicine evaluating the survival effect of these patients being treated by a criticalist specifically, but at this point the recommendation is to hospitalize these patients at a 24 hour facility with the ability to closely monitor and treat critically ill patients on a minute-by-minute basis.

REFERENCES:

Smarick SD, Haskins SC et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 6: post-cardiac arrest care. J Vet Emerg Crit Care 2012; 22(S1): S85-S101.

Kirby, R. "Golden Rule of Emergency Medicine - and More!" Conference proceedings: International Veterinary Emergency and Critical Care Symposium 2009.